

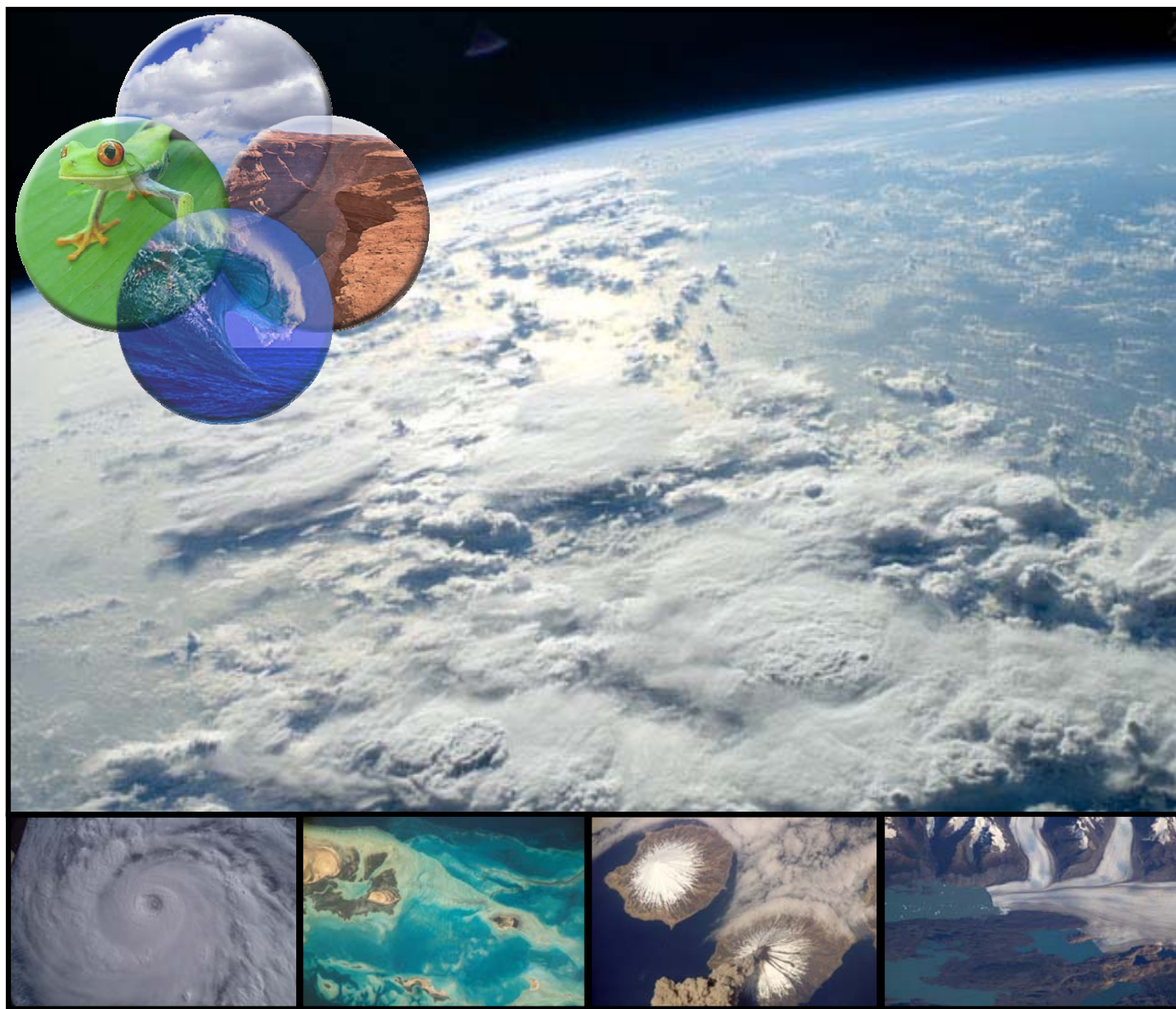


National Aeronautics and
Space Administration

SPHERES OF EARTH

An Introduction to Making Observations of Earth Using an
Earth System Science Approach

STUDENT GUIDE



ARES

Astromaterials Research & Exploration Science



National Aeronautics and
Space Administration

SPHERES OF EARTH

An Introduction to Making Observations of Earth Using an Earth System Science Approach

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Front cover images courtesy of the ARES Image Science and Analysis Laboratory, NASA JSC.

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SPHERES OF EARTH

Part 1: Systems and Features

Earth is a diverse planet. What makes up our planet and how does it work? Earth System Science is one way to think about the different parts or systems that make up Earth as a whole. In the first part of this activity you will think about Earth systems and the different features that can be associated with those systems. To help you get started, let's first look at an example using the human body.

Understanding Systems: Using the Human Body as an example

The human body is made up of a set of systems that work together to help our bodies function properly. Each system has a specific function and has various parts/features. The table below lists a few example body systems, a key word or phrase we can associate with each system, and a few parts of the body that make up that system (system features).

SYSTEM	KEY WORD(S)	SYSTEM FEATURES
Circulatory	Blood movement	1) Blood 2) Veins 3) Arteries
Skeletal	Bone structure	1)Tibia 2) Femur 3) Radius
Respiratory	Breathing	1) Lungs 2) Trachea 3) Alveoli

Our bodies need each and every one of its systems. Doctors often specialize in one body system, but need to understand how the body works as a whole. Earth functions in the same way. All Earth systems are linked and each one is necessary to keep our Earth in balance.

The Earth Systems are sometime called the *spheres* of Earth. Using the example above, think about what you may know about Earth systems and fill in the table below. Use the word bank to help you.

SYSTEM	KEY WORD	SYSTEM FEATURES (list 3 features)
Atmosphere		1) Dust storms 2) 3)
	Land	1) Mountains 2) Volcanoes 3)
Hydrosphere		1) Lakes 2) 3)
	Life	1) Plankton 2) Coral Reefs 3)

Word bank: *Glaciers* *Hurricanes* *Water* *Clouds* *Oceans*
 Forests *Biosphere* *Impact Craters* *Air* *Litho/Geosphere*

As you continue with this activity you will learn more about each system. You will also observe many different features in stunning images of Earth taken by astronauts. As you observe each image, take note that features from multiple spheres are almost always visible. Let's learn more!

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Part 2: Background Information & Data Collection

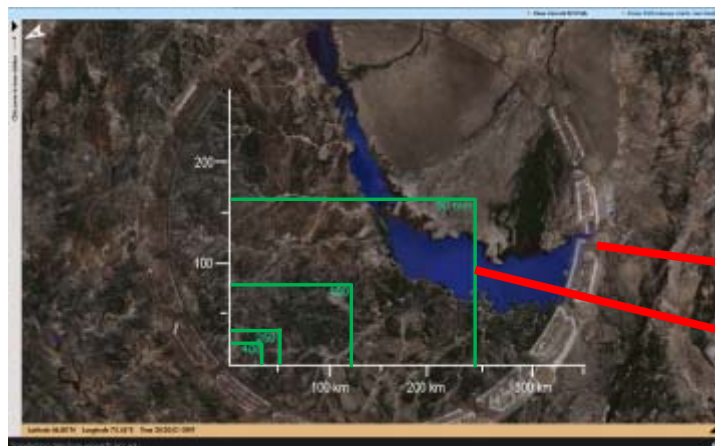
Background Information

CREW EARTH OBSERVATIONS (CEO)

Scientists from the Image Science and Analysis Laboratory (ISAL) at NASA's Johnson Space Center (JSC) work with astronauts onboard the International Space Station (ISS) who take images of Earth. Astronaut photographs, sometimes referred to as Crew Earth Observations, are taken using hand-held digital cameras onboard the ISS. These digital images allow scientists to study Earth from the unique perspective of space.

Astronauts have taken images of Earth since the 1960s. There is a database of over 900,000 astronaut photographs available at *The Gateway to Astronaut Photography of Earth* website (<http://eol.jsc.nasa.gov>). Images are requested by ISAL scientists at JSC and astronauts in space personally frame and acquire them from the Destiny Laboratory window or other windows in the ISS. By having astronauts take images, they can specifically frame them according to a given request and need. For example, they can choose to use different lenses to vary the amount of area or detail an image will include. Images can be taken at different times of the day. This allows different lighting conditions to bring out or highlight certain features. The viewing angle at which an image is taken can also be varied to show the same area from different perspectives. Nadir views are when an image is taken with the camera pointing straight down. Oblique views are when an image is taken with the camera pointed at an angle. Being able to change these variables makes astronaut photographs a unique and useful data set.

Astronaut photographs are taken from the ISS from altitudes of 300 – 400 km (~185 to 250 miles). One of the current cameras being used, the Nikon D3X digital camera, can take images using a 50, 80, 180, 250, 400, or 800mm lens. These different lenses allow for a wider or narrower area to be included in an image. Generally, the higher the camera focal length (400mm for example) the smaller area imaged. Higher focal lengths also show greater detail of the features in an image.



The image shown here illustrates what an astronaut would see looking out the Destiny window from the ISS. You can see the circular outline of the window as well as the amount of surface area that would be imaged with different lenses.

Outline of Destiny window

Green boxes indicate the approximate area covered in images taken with different lenses.

Image source: *Windows on Earth* website: <http://winearth.terc.edu/app/ISSFlight>

EARTH SYSTEM SCIENCE

Our diverse planet Earth has so many different features that can be studied from space. One approach to studying Earth is by taking an Earth Systems Science approach. As you may remember from Part 1 of the activity, Earth Systems Science involves looking at Earth as a set of systems. These systems are all connected and influence one another as well as the Earth as a whole. Each individual system consists of features that together play a role in keeping our Earth in balance. A change within one system will cause a change in another. The past, present, and future of our planet is based on the constant interaction among these systems.



Let's take a closer look at each individual Earth system or sphere, and associated features you can observe in astronaut photographs:

1. **Atmosphere:** This sphere relates to meteorological features and phenomena such as weather, clouds, or aerosols (particles in the air). It includes an ever-changing ***mixture of gas and small particles located above and surrounding the Earth's surface***. Features include:

-Clouds	-Hurricanes and Cyclones	-Aurora
-Air Pollution/Aerosols	-Dust and Sand Storms	

2. **Biosphere:** This sphere is associated with ***living systems*** such as ***biomes*** or ***ecosystems***. This includes life on land, in the oceans and rivers, and even life we cannot see with the naked eye. Features we can observe in astronaut photographs include:

-Coastal Biomes	-Forests	-Deserts
-Grasslands	-Urban/Agricultural Ecosystems	

3. **Hydrosphere:** This sphere is associated with ***water in solid (ice) and liquid states***. Water in a gas state (water vapor) is probably best considered as a feature of the atmosphere. Features include:

-Oceans	-Lakes and Rivers	-Snow
-Ice Bergs	-Glaciers	

4. **Litho/Geosphere:** This sphere is associated with solid portions of the Earth. It includes rocks, sediments and soils, ***surface landforms*** and the ***processes*** that shape the surface. Features associated with this sphere can be broken down into a variety of different processes and related surface landforms. These are:

- Fluvial & Alluvial Processes:*** Valley networks, river channels/canyons, deltas, alluvial fans
- Aeolian Processes:*** Sand dunes, yardangs, wind streaks
- Tectonic Processes:*** Folds, faults, mountains
- Volcanic Processes:*** Volcanoes, central vents, volcanic deposits
- Impact Processes:*** Impact craters
- Other Processes:*** Mass wasting processes, erosional processes

EARTH SYSTEM CONNECTIONS

As scientists focus on features within one Earth system, they must consider the influences from other systems. Influences and visible effects can sometimes be obvious and other times may go almost unnoticed. There may be some effects that are immediate, and others that may not be realized for years. Let's take the oil spill off the coast of Louisiana as an example. There were definite effects on the hydrosphere (ocean) from the spill. You could immediately see the oil in the Gulf in images taken from space. But did this spill potentially affect other spheres? Unfortunately, it did. First, think of the gases and smoke that went into the atmosphere when the explosion occurred. The biosphere (marine life and coastal ecosystems) were certainly harmed by the spill as well. As the oil reached land, it became mixed in and absorbed into the soils and sediment along the coast. These effects cannot all be observed in a single image. Scientists studying the effects on different Earth systems would also likely look at a variety of different data sets, depending on their research, in addition to images.

As you make observations of images, think about how a change in one feature/system may play a role in changing another. Keep in mind that that changes can be caused from naturally occurring events like hurricanes, volcanic eruptions, or earthquakes, or from human influences.

The images below are astronaut photographs. As you make observations of these images and others, you will almost always see features representing different systems. Think about the features, the system they are related to, and how a change in one system may affect features in another. The next part of this activity will let you to explore and discover more astronaut images from space!



This image shows a variety of features. It includes glaciers (hydrosphere), a lake (hydrosphere), mountains (litho/geosphere) and snow or ice (hydrosphere).

If there is more snow (hydrosphere) the glaciers will grow and eventually flow into the lake. They may also carve deeper valleys into the mountains (litho/geosphere). As the glaciers break off and melt, this will cause the lake levels to rise (hydrosphere).

Image ID#: ISS003-E-6061



This image contains features such as an island/atoll (litho/geosphere), coral reefs (biosphere), sand deposits (litho/geosphere), the ocean (hydrosphere), clouds (atmosphere), and vegetation (biosphere).

If sea levels were to rise (hydrosphere) this could change the coastline (litho/geosphere) of this island. Sand deposits (litho/geosphere) would possibly end up under water and vegetation and any life forms (biosphere) that lived off that vegetation would not be able to survive.

Image ID#: ISS018-E-18129



SPHERES OF EARTH

Part 2: Background Information & Data Collection

Discovering and Exploring Features on Earth Visible from Space

Now that you know a little bit about Earth systems and features, let's have you discover and explore features on Earth that are visible from space in astronaut photographs.

Directions:

1. Go to the Gateway to Astronaut Photography of Earth website: <http://eol.jsc.nasa.gov/>
2. You will see 4 search tabs at the top of the page: "Find Photos", "Collections", "Information", "Where is Your ISS"? Look under the "Find Photos" tab and select "Weekly Top 10."



3. For each of the Weekly Top 10 images there is a thumbnail of the image that shows you a small snapshot of the picture. To the right of each thumbnail, information is provided about the image. The important information to note is the image identification number and the brief description of features or the geographic location of the image. Click on the *Image Identification number* to view the image and additional metadata (details about that image).





4. Once you click on the Image ID#, a new page will open showing the astronaut photograph along with all the metadata, which are important details about the image. It is important to be able to sort through the metadata to find important information that will be useful for you to log. Scroll down the webpage to locate the following metadata you would most commonly want to log.
 - a. Image Identification number: This is a unique identifier for any given image. This number should appear at the top of the image you are viewing.
 - b. Country or Geographic Name: It is interesting to learn where certain features are found on Earth. Learning about the geography of Earth is also useful!
 - c. Features: Be aware that the “features list” provided on the website may not include all features visible in the image. You can revise and/or add information on your log sheet.
 - d. Center Point Latitude and Longitude: This will allow you to locate this image on a map of Earth. Be sure to log the center latitude and longitude of the image and not the nadir point (location point straight down) from the spacecraft.
 - e. Camera Used: Current images are often taken with the Nikon D2 and D3 camera series, but other cameras (Hasselblad, Kodak DSC760, etc.) have been previously used.
 - f. Camera Focal Length: The focal length gives you an idea of the field of view or if a wide or narrow area is covered in the image. The higher the focal length, the narrower (smaller) the area.
 - g. Date Acquired: It is useful to know when an image was taken so you can perhaps look at images taken of that same area on a different date and make comparisons.
 - h. Caption: If a caption is written, it can provide you with background information about the image or geographic area. You are encouraged to read it and pull out important information to help you understand what you are observing in an image.
5. It is also extremely important to log your own observations of each image. Information to include is as follows:
 - a. Features Observed in the image along with their associated sphere or Earth system: This will help you start to differentiate between Earth’s systems and features associated with those systems. You can certainly use features already listed from the website, but you are encouraged to list features *you* can identify.
 - b. Miscellaneous Observations: This allows you to list general statements, questions, observations, or sketches of the image you are observing.

Now you are ready to collect data!

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Part 2: Background Information & Data Collection

Use the Data Collection sheet below to log data and observations of at least 4 images. To view images do the following: 1) Go to <http://eol.jsc.nasa.gov>; 2) Go to the “*Find Photos*” tab and select “*Weekly Top 10*” and choose an image to observe.

Astronaut Photography Image Metadata and Observations		
Image ID#:	Latitude (N):	Longitude (E):
Camera Used:	Lens Focal Length:	
Date Acquired:	Country/Geographic Region:	
Background information about image:		
List 3 Visible Features, Associated Earth System, and Observations		Miscellaneous Observations, Sketch, or Questions
Feature: _____ Earth System: _____ Observations of feature: _____ Feature: _____ Earth System: _____ Observations of feature: _____ Feature: _____ Earth System: _____ Observations of feature: _____		

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Image ID#:	Latitude (N):	Longitude (E):
Camera Used:	Lens Focal Length:	
Date Acquired:	Country/Geographic Region:	
Background information about image:		
List 3 Visible Features, Associated Earth System, and Observations		Miscellaneous Observations, Sketch, or Questions
Feature: _____ Earth System: _____ Observations of feature: _____ Feature: _____ Earth System: _____ Observations of feature: _____ Feature: _____ Earth System: _____ Observations of feature: _____		

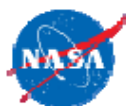


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Date Acquired:	Country/Geographic Region:	
Background information about image:		
List 3 Visible Features, Associated Earth System, and Observations		Miscellaneous Observations, Sketch, or Questions
Feature: _____ Earth System: _____ Observations of feature:		
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Astronaut Photography Image Metadata and Observations		
Image ID#:	Latitude (N):	Longitude (E):
Camera Used:	Lens Focal Length:	
Date Acquired:	Country/Geographic Region:	
Background information about image:		
List 3 Visible Features, Associated Earth System, and Observations		Miscellaneous Observations, Sketch, or Questions
Feature: _____ Earth System: _____ Observations of feature:		
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Feature: _____ Earth System: _____ Observations of feature:		

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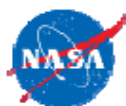
Part 3: Presentation of Observations

You have now observed at least 4 astronaut photographs and have identified a variety of visible features. You should now be more familiar with the different Earth Systems.

You will present one the images you logged data for and explain to your classmates what you have discovered. **Use the table below as a guide for your presentation.**

Image ID#			
Background information about image and its location			
Observations of 3 features and associated Earth system	Feature: _____ System: _____ Observations of feature:	Feature: _____ System: _____ Observations of feature:	Feature: _____ System: _____ Observations of feature:
Describe how you think changes to one feature/system may affect others			
List 1 question about a specific feature(s) that interest you			

As each group presents information about one of the images they observed, be sure to take notes. Use the table on the next page as a guide for your notes. Be sure to log comments about the image or features you found interesting.



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Part 3: Presentation of Observations

STUDENT PRESENTATION NOTES:

Student Presenters and Image ID#			
Observations of 3 features and associated Earth system	Feature: _____ System: _____ Observations:	Feature: _____ System: _____ Observations:	Feature: _____ System: _____ Observations:
Comments about image or features you found interesting			

Student Presenters and Image ID#			
Observations of 3 features and associated Earth system	Feature: _____ System: _____ Observations:	Feature: _____ System: _____ Observations:	Feature: _____ System: _____ Observations:
Comments about image or features you found interesting			

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Part 4: Research Planning

Based on your observations of images and presentations given by your classmates, answer the following questions. This may help you get started on a possible research investigation.

1. List three visible features observed in images that interest you, along with their associated Earth system. In the third column, indicate a specific aspect of each feature you find interesting that could become the focus of future research. An example has been provided for you.

Feature	Earth System	Aspect of feature that is interesting
<i>Example: Hurricanes</i>	<i>Atmosphere</i>	<i>The eye of the hurricane.</i>
1.		
2.		
3.		

2. Think about each of the features and aspects you listed above. Focusing on one of those feature aspects, create a question that could be investigated further using astronaut photography. Include an explanation of what methods you would use to go about answering that question. Be as detailed as possible including what specific data/metadata you would want to log from each image observed. (Use additional paper if necessary.)

Feature Aspect	<i>Example: Eye of Hurricanes</i>	
Question	<i>How does the eye of a hurricane change as the strength of the storm changes?</i>	
Explanation of Research Methods	<i>I would need to look at images of multiple hurricanes & make observations of the eye at different hurricane strengths. I would log the image id#, location of hurricane, hurricane name, date & time of each image, camera lens, hurricane strength, log observations of visible changes to the eye, & sketch of the eye from each image.</i>	

SPHERES OF EARTH

Part 5: System and Feature Review

You are now familiar with the four spheres of Earth and different features that can be associated with those spheres. You should also realize that although you can focus on individual features as part of an investigation, any change to one feature/system will have an effect on others. In this part of the activity, you will review what you have learned!

1. Fill in the information on the table below. Be sure to name each sphere of Earth as well as 2 features that are related to that system.

SYSTEM/SPHERE	KEY WORD	SYSTEM FEATURES (list 2 features)	
	Air	1)	2)
	Land	1)	2)
	Water	1)	2)
	Life	1)	2)

2. Describe one example of how a change in one feature/system can affect another: